Condensed Matter Physics

PROTON NMR RELAXATION STUDY OF $CsHSO_4$

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Many solid acid systems, including $CsHSO_4$, exhibit superprotonic phase transitions in which their hydrogen ion conductivities increase by several orders of magnitude at temperatures between 50 and 150º C. Technologically, enhanced hydrogen ion conductivity is important for the development of electrolytes for fuel cells. In order to study this transition in $CsHSO_4$, proton spin-spin relaxation times have been measured from 37 to 160º C. NMR relaxation theory predicts the presence of two T_2 relaxation regimes (rigid lattice and motionally narrowed regimes). Within this model, atomic motions are thermally activated and can be characterized by a single correlation time at each temperature. In the rigid lattice regime, motions are too slow to average dipole-dipole interactions on the NMR time scale, thus, T_2 is essentially constant. In the motionally narrowed regime atomic motions tend to average local magnetic fields to zero; thus, as the rate of atomic motion increases, T_2 increases proportionally. In our experiments, T_2's are nearly constant (100 us) over the temperature range from 37 to 100º C, indicating hydrogen motions are effectively frozen out (rigid lattice regime). In the regime of the superprotonic phase transition (~140º C), T_2 increases dramatically (up to approximately 250 times its low temperature value). A model to explain the results in view of hydrogen ion conductivity is presented.